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(56) Documents cited
GB 2219688 A GB 1448322 A GB 1412849 A
GB 0995188 A GB 0979589 A GB 0957117 A
US 4785172 A

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(54) Mass spectrometer

(57) A mass spectrometer 20 has an ion source 22 which connects with a tubular pump line 26 and with a section 30 inclined relative to the source 22. A flight tube 36 connectably extends from the side of the section 30 towards the axial direction of the source 22 and curves through a right angle. A permanent magnet 40 is provided which overlaps below and above the flight tube 36, wherein the face of the magnet 40 which faces the section 30 is convex such that the focal point of all the deflected ion beams lies substantially on a straight line within and parallel to the section 30. One or more ion collectors 48 are slidably mounted within the section 30 and movable as required along spaced bars 50 to detect different masses.

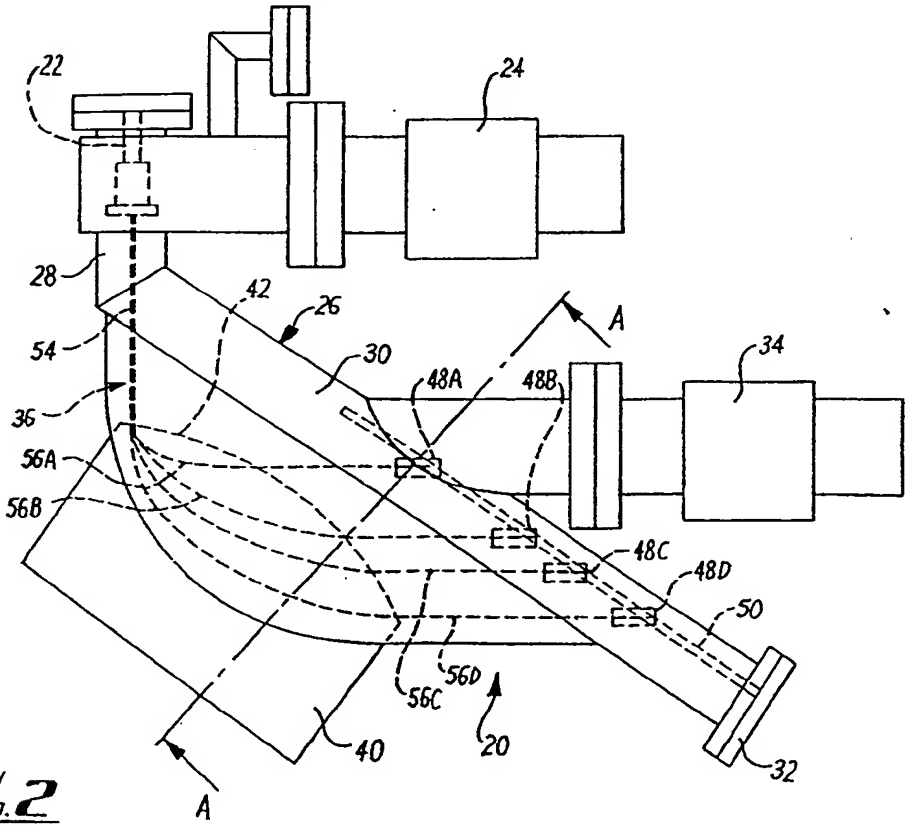

FIG.2

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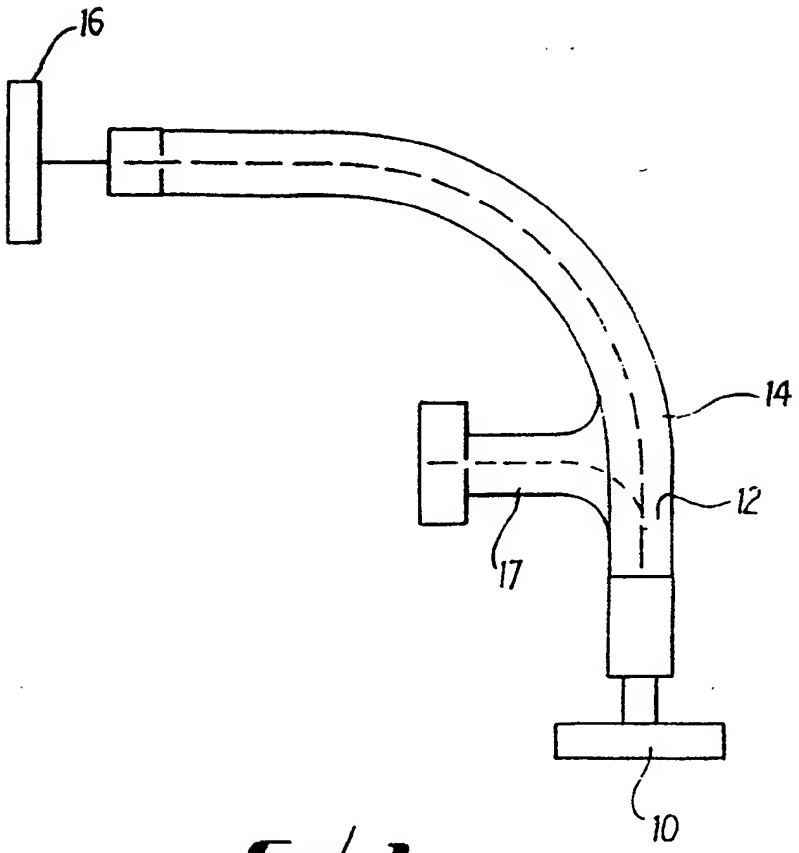

FIG. 1

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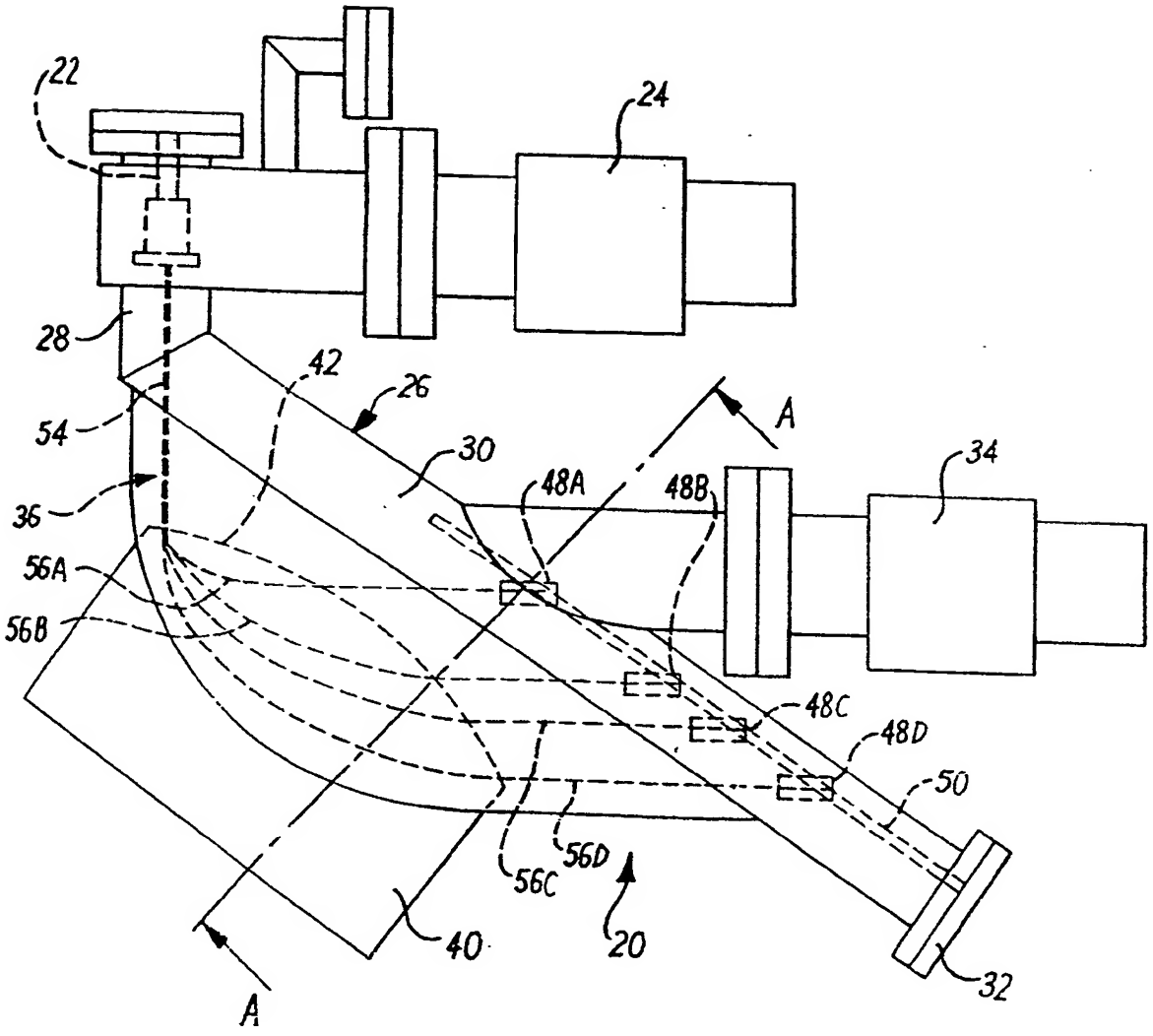

FIG. 2

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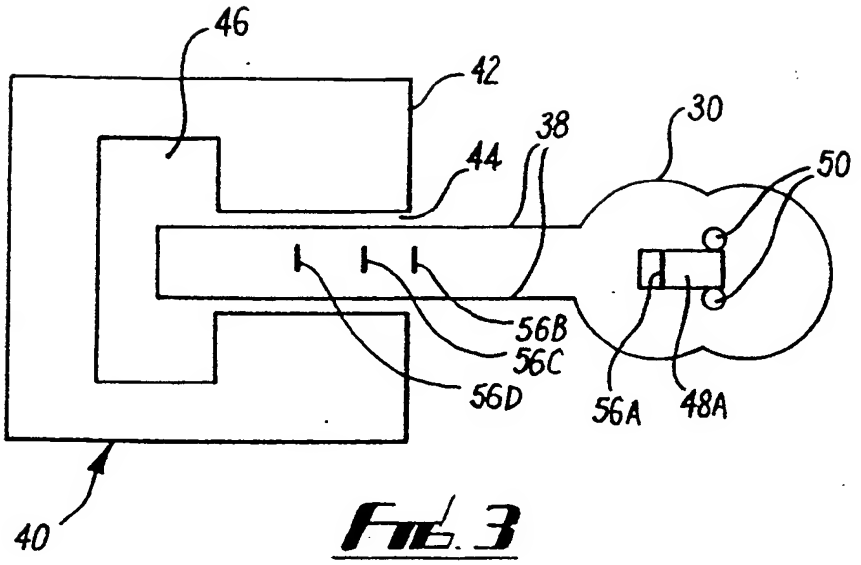

FIG. 3

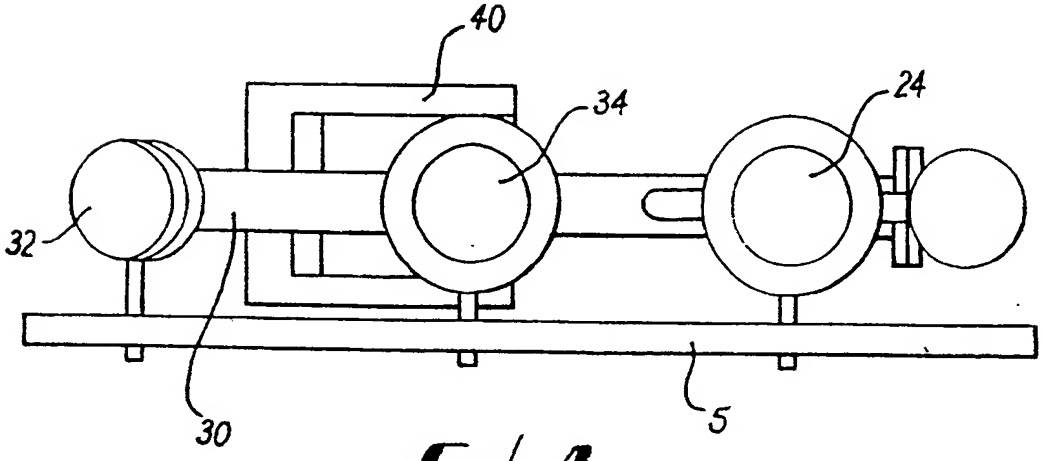

FIG. 4

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Improved Mass Spectrometer

This invention concerns improvements in or relating to mass spectrometers.

In a mass spectrometer an accelerated beam of ions of a substance to be analysed is produced and passed through a magnetic field. The amount of deflection of the beam in the field is dependent on the mass and charge of the ions. The deflected beam is measured to provide an indication of the constituent components of the substance.

Fig. 1 is a diagrammatic plan view of a conventional mass spectrometer. The spectrometer of Fig. 1 comprises an ion source 10 producing a focussed beam of accelerated positive ions 12. The source 10 connects with a flight tube 14 located adjacent to which is a magnet (not shown). The magnet causes the beam 12 to be deflected. The tube 14 subsequently leads to a collector 16. The front of the collector 16 is in the form of a slit such that only a part of the beam 12 travelling at a particular inclination is measured. The source 10 as is conventional is aligned substantially perpendicular to the collector 16. All the components of the spectrometer shown in Fig. 1 are evacuated so that even solids with a very low vapour pressure can be

sampled.

To scan the substance being analysed the velocity of the beam 12 may be varied. Alternatively or in addition, in the case when an elctromagnet is used, the magnetic field may be varied. Electomagnets provide for much slower analysis than permanent magnets and require inductance and other similar effects to be taken into account. In the case of a permanent magnet, if it is required to analyse for widely varying molecular masses, a second collector would generally be required which would require an extra port 17 extending from the flight tube 14. This will complicate the apparatus and be expensive, and make the spectrometer difficult to set up.

According to the present invention there is provided a mass spectrometer comprising means for producing a beam of ions, means for producing a magnetic field through which the beam passes and is thereby deflected and dispersed, and means for analysing one or more parts of the deflected beam and producing a signal corresponding to the or each said part of the beam, the apparatus being arranged such that the focal point of each of the constituent parts of the deflected beam lies substantially on a straight line.

Preferably the magnetic field producing means comprises a magnet shaped to produce the linear focal point alignment. The magnet is preferably a permanent magnet and may have a convex face. Alternatively, or in addition, the magnet may have a stepped face. The convex or stepped face preferably faces substantially towards the line upon which the focal points lie.

Said line is preferably inclined between 40° and 72° relative to the alignment of the ion beam prior to deflection, and desirably substantially 56°.

The analysing means is preferably movably located substantially on said line and is desirably slidably movable therealong for analysis of different parts of said dispersed beam. A plurality of analysis means may be provided along said line.

Means are preferably provided for substantially evacuating the apparatus. Pumping means may be provided such that the pressure at the analysing means is lower than at the beam producing means. Separate pumping means are preferably provided for evacuating the area around the analysing means and the area around the beam producing means.

The or each analysing means is preferably located

wholly within a passage with an opening facing the magnet, said passage preferably leads to the pumping means for the area around the analysing means. Said passage is also desirably substantially parallel to and contains the focal point line. Connections to the or each analysing means preferably enter the passage through one end thereof.

An embodiment of the present invention will now be described by way of example only with reference to figures 2 - 4 of the accompanying drawings, in which:-

Fig. 2 is a diagrammatic plan view of a mass spectrometer according to the invention;

Fig. 3 is a diagrammatic cross sectional view on the line A-A of Fig. 2; and

Fig. 4 is a side view of the apparatus taken from the right hand side of the apparatus as shown in Fig. 2.

Figs. 2-4 show a mass spectrometer 20 with an ion source 22. The source 22 is of a conventional construction and will thus not be described in any detail in this specification. A first vacuum pump 24 on a mounting extends laterally from the source 22 for evacuation thereof.

The source 22 connects with a tubular pump line 26. The line 26 comprises a first relatively short section 28 coaxial with the source 22 and a second

section 30 inclined at an angle of substantially 56° to the section 28 and closed at the far end 32 thereof. A second vacuum pump 34 is connected to the section 30 at a generally midpoint thereof.

A flight tube 36 connectably extends from the side of the section 30 towards the axis through the source 22. The tube 36 is defined by a pair of parallel plates 38 spaced from each other a distance less than the radius of the line 26. The side edge of the tube 36 away from the section 30 is closed and extends from a location closely adjacent the section 28 and runs initially parallel to the axis of the latter before curving through a right angle to join with the section 30 spaced inwardly of the free end thereof. A permanent magnet 40 is formed substantially as an open-ended channel 46 having a channel mouth 44 opening horizontally in use towards the section 30. The side walls of the channel are of increased width at the channel mouth 44 whereby to define a mouth of a reduced dimension relative to that of the channel 46. The outermost edges 42 of the channel side walls are convex and the magnet 40 is located such that the curved part of the tube 36 extends through the channel mouth into the channel over its curved length. The curved edges 42 of the magnet are shaped such that the focal point of all the deflected dispersed ion beams lie substantially

on a straight line within and parallel to the section 30.

A pair of spaced bars 50 extend from the far end 32 of the section 30 for a considerable part of the length thereof. Slidably mounted on the spaced bars 50 are four collectors 48 A, B, C and D. The collectors 48A-D are of a conventional design comprising a slit in front of a "Faraday bucket" and shall therefore not be described in detail. Fig.4 shows the mounting of the above described components on a base plate 52 and illustrates the planar arrangement of the spectrometer 20.

In use, the collectors 48A-D are positioned on the bars No 50 as required, depending on the components to be analysed. A beam No 54 of positive ions of the substance being analysed is produced by the source 22. The beam 54 passes through the section 28 and into the flight tube 36. As the beam 54 passes through the slot 44 the beam 54 is dispersed.

In Fig. 2 four beams 56A-D are shown diagrammatically corresponding to the collectors 48A-D. The beams 56A-D correspond respectively to components of increasing molecular mass. As can be seen from Fig. 2 the beam 56A corresponding to the component of

lowest mass is deflected the most. The beams 56A-D will be sensed by the collectors 48A-D and a suitable signal produced. In order to improve performance differential pumping is applied by producing a higher vacuum with pump 34 than pump 24.

There is thus described a mass spectrometer which permits a number of constituent components of a substance to be simultaneously analysed. The number and positioning of the collectors can obviously be varied as required thus making the spectrometer very flexible and in many instances a single collector would be sufficient. The provision of the collectors in the pumping line provides for a very compact arrangement. Further this arrangement permits a very wide range of molecular mass to be analysed without the requirement of for example extra ports.

Various modifications may be made without departing from the scope of the invention. For example, as mentioned above any number of collectors may be used. The magnet may be of a different shape and the face of the magnet facing towards the pumping line may be stepped rather than curved or a mixture of both. If required, an electromagnet could be used providing for even greater flexibility of the spectrometer. Differential pumping could be dispensed with and in this

instance only a single vacuum pump would be required. Instead of Faraday Bucket Collectors secondary emission collectors may be used.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

CLAIMS

1. A mass spectrometer comprising means for producing a beam of ions, means for producing a magnetic field through which the beam passes and is thereby deflected and dispersed, and means for analysing one or more parts of the deflected beam and producing a signal corresponding to the or each said part of the beam, the apparatus being arranged such that the focal point of each of the constituent parts of the deflected beam lies substantially on a straight line.

2. A spectrometer according to Claim 1, in which the magnetic field producing means comprises a magnet shaped to produce the linear focal point alignment.

3. A spectrometer according to Claim 2, in which the magnet is a permanent magnet.

4. A spectrometer according to Claims 2 or 3, in which the magnet has a convex face.

5. A spectrometer according to Claim 4, in which the convex face faces substantially towards the line upon which the focal points lie.

6. A spectrometer according to any of Claims 2 to 5, in which the magnet has a stepped face.

7. A spectrometer according to Claim 6, in which the stepped face faces substantially towards the line upon which the focal point lies.

8. A spectrometer according to any of the preceding Claims, in which the focal point line is inclined at between 40° and 72° relative to the alignment of the ion beam prior to deflection.

9. A spectrometer according to Claim 8, in which the focal point line is inclined at substantially 56° relative to the alignment of the ion beam prior to deflection.

10. A spectrometer according to any of the preceding Claims, in which the analysing means is movably located substantially on the focal point line.

11. A spectrometer according to Claim 10, in which the analysing means is slidably movable along the focal point line for analysis of different parts of said dispersed beam.

12. A spectrometer according to Claims 10 or 11, in which a plurality of analysis means are provided along said line.

13. A spectometer according to any of the preceding Claims, in which means are provided for substantially evacuating the apparatus.

14. A spectrometer according to Claim 13, in which pumping means are provided such that the pressure at the analysing means is lower than at the beam producing means.

15. A spectrometer according to Claim 14, in which separate pumping means are provided for evacuating the area around the analysing means and the area around the beam producing means.

16. A spectrometer according to any of Claims 2 to 15 when dependent on Claim 2, in which the or each analysing means is located wholly within a passage with an opening facing the magnet.

17. A spectrometer according to Claim 16 when dependent on Claim 15, in which the passage leads to the pumping means for the area around the analysing means.

18. A spectrometer according to Claims 16 or 17, in which the passage is substantially parrallel to and contains the focal point line.

19. A spectrometer according to any of Claims 16 to 18, in which connections to the or each analysing means enter the passage through one end thereof.

20. A mass spectrometer substantially as hereinbefore described with reference to the accompanying drawings.

21. Any novel subject matter or combination including novel subject matter disclosed in the foregoing specification or claims and/or shown in the drawings, whether or not within the scope of or relating to the same invention as any of the preceding claims.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number 9023630.8

Relevant Technical fields

(i) UK Cl (Edition K) HID-DMAA; DMD; DMF

(ii) Int Cl (Edition 5) HOIJ

Search Examiner

R H LITTLEMORE

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

30 January 1991

Documents considered relevant following a search in respect of claims 1-20

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2219688A (JOEL) See figure 3	1-3 at least
X	GB 1448322 (UNIVERSITY OF ROCHESTER) See figures 2-4	1-3,12 at least
X	GB 1412849 (AEI) See figures 1-4	1-3,12 at least
X	GB 995188 (BENDIX) See figure 1	1-3,12 at least
X	GB 979589 (ATLAS-WERKE) See figures 1-3	1-3,8,9 at least
X	GB 957117 (AEI) See figures 1 and 2	1-3 10-12 at least
X	US 4785172 (KUBENA) See figure 2	1-3,12 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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